Braddock Bay Restoration

2016 Monitoring and Adaptive Management Report

Buffalo District

U.S. Army Corps of Engineers

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Executive Summary

This document presents the results of the 2016 monitoring and adaptive management surveys conducted at Braddock Bay (the Bay). The purpose of this monitoring effort was to collect data that can be used to assess if the Braddock Bay restoration project has been successful in achieving its objectives and to support local resource agencies and stakeholders in adaptive management. These sampling results characterize the first growing season after wetland restoration activities. As construction of the barrier beach did not begin until August of 2016, surveys of aquatic vegetation within the bay, water quality, and erosion of the emergent wetland shoreline reflect pre-construction conditions. For the same reason, evaluation of littoral drift impacts and navigation impacts were not completed as part of this study.

Monitoring tasks conducted in 2016 included surveys of emergent marsh vegetation, submerged aquatic vegetation, fish, birds, anurans, and water quality. High resolution aerial imagery was also collected through the use of an Unmanned Aerial Vehicle (UAV) and was used to assess erosion of emergent marsh shoreline.

Monitoring results were compared to performance criteria to determine if conditions following restoration have been improved so as to meet the project objectives. Monitoring components related to the wetland habitat diversity and wetland habitat suitability objectives were in partial attainment of performance criteria during 2016 monitoring. Monitoring components related to the reducing erosion objective and the various project constraints (littoral drift, navigation and trophic state) were not evaluated as the barrier beach had not been completed by at the time of monitoring field work. These will be evaluated in more detail in 2017. The recommendation from 2016 monitoring is to continue data collection in 2017.

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Appendices

1.0 Purpose and Background

This document presents the results of the 2016 monitoring and adaptive management surveys conducted at Braddock Bay (the Bay). The purpose of this monitoring effort was to collect data that can be used to assess if the Braddock Bay restoration project has been successful in achieving its objectives and to support local resource agencies and stakeholders in adaptive management.

As described in the Braddock Bay Restoration: Monitoring and Adaptive Management (Appendix A), post-restoration monitoring data is to be compared to pre-determined ecologic performance criteria to assess the status of the resource and determine if adaptive management actions are required. In some cases, sampling in 2015 and 2016 provided additional baseline data for which to compare future conditions. In these cases, performance criteria have been updated to reflect new baseline data or data from control sites.

1.1 Adaptive Management Approach

Adaptive Management prescribes a process wherein management actions can be changed in response to monitored system response, so as to maximize restoration efficacy or achieve a desired ecological state. Adaptive management promotes flexible decision-making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders (NRC, 2004).

Adaptive ecosystem based management has become a fundamental practice being applied to a variety of environmental protection and restoration actions within New York State (NYS) Great Lakes basin. Adaptive management principles described below are consistent with, although not necessarily identical, to those principles being implemented through Bi-national Great Lakes Water Quality Act the International Joint Commission, Great Lakes Adaptive Management Committee, the US ocean policy, and NYS Great Lakes action agenda.

New York's Great Lakes action agenda includes 2 specific actions for monitoring and evaluating beneficial use restoration efforts in AOCs. These monitoring actions follow the steps of adaptive management outlined by Great Lakes Action Agenda (2014) they are:

1. **Conceptualize the problem** by defining the scope, vision, targets and complete situation analysis;

2. **Plan Actions and Monitoring** through development of goals strategies and assumptions. Develop an operation and monitoring plan;
3. **Implement** the Actions and Monitoring by developing a work plan and timeline;
4. **Analyze Use and Adapt the plan** through analysis of the data, and change the plan if necessary to achieve the stated goals and objectives; and
5. **Share the output** of the plan in an outreach or educational environment.

Figure 1. Adaptive management steps from New York's Great Lakes action agenda.

1.2 Project Goals and Objectives

The primary purposes of monitoring efforts is to assess if the project objectives have been achieved and project constraints have been avoided. As stated in the Feasibility Report (September 2014), the planning objectives are as follows:

1. Restore wetland and habitat diversity in Braddock Bay to improve its suitability for fish and wildlife including northern pike, American mink, and the state listed black tern during the planning period of 2015-2065.
2. Protect Braddock Bay wetlands from erosion during planning period of 2015 – 2065.

Four critical project constraints are also being assessed through monitoring and adaptive management plan:

1. Avoid negatively impacting navigability and operation of marinas within bay.
2. Avoid impacts to nutrient dynamics of Braddock Bay that will worsen eutrophication.
3. Avoid negative impacts to Lake Ontario littoral drift system.

4. Avoid project activities that will increase extent of invasive species at pro

ject site.

1.3 Specific Monitoring Components

The adaptive management plan will focus on addressing key uncertainties associated with the proposed restoration plan. These uncertainties have potential to impact the degree to which project objectives are achieved and project constraints are avoided. In order to adequately determine if restoration outcomes have achieved the project objectives and avoided constraints, the monitoring plan will address the following components:

1. Vegetative diversity of Braddock Bay wetland (Objective 1)
2. Fish and wildlife diversity of Braddock Bay wetland (Objective 1)
3. Erosion rate of central marsh (Objective 2)
4. Navigability of bay mouth (Constraint 1, 3)

5. Water chemistry parameters specific to trophic status (Constraint 2)
6. Local littoral sediment transportation (Constraint 3)
7. Invasive species presence in restoration areas (Constraint 4)

1.4 Monitoring Framework

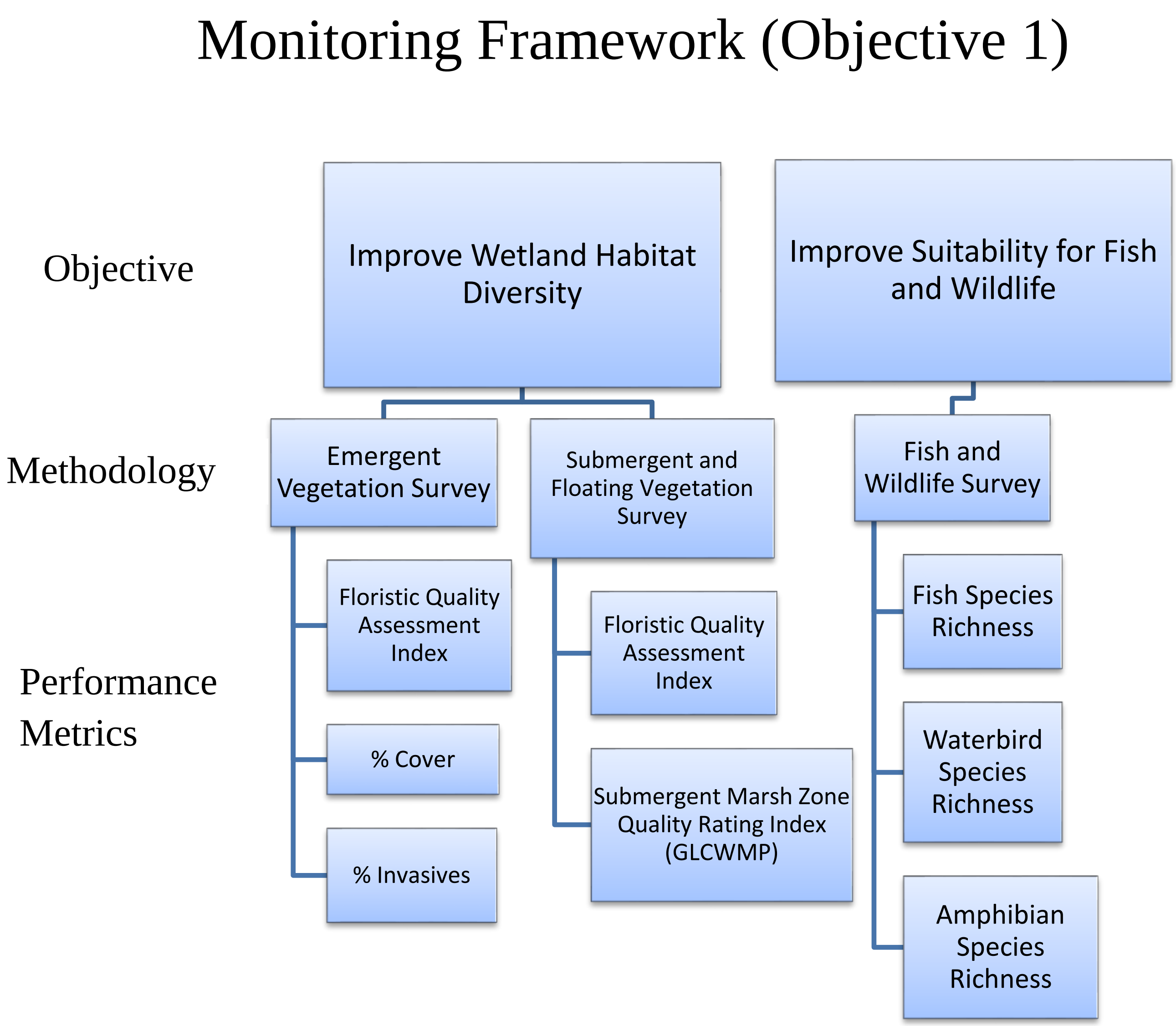


Figure 2. Monitoring Framework for Objective 1

Monitoring Framework (Objective 2)

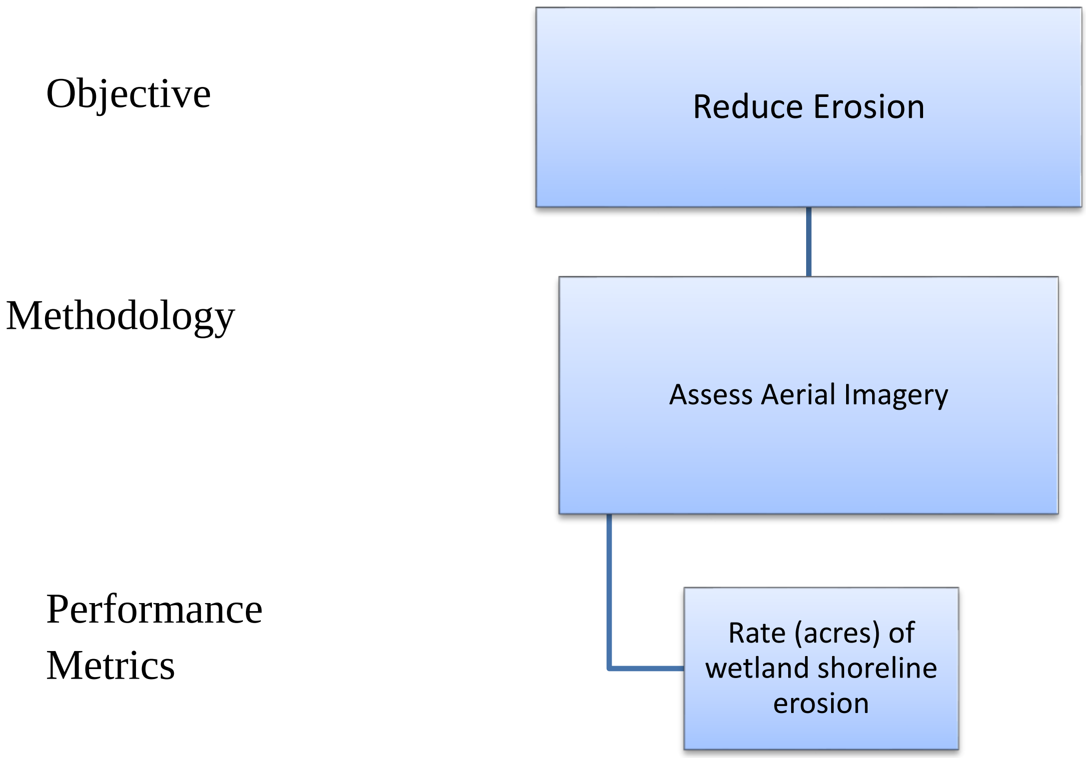


Figure 3 Monitoring Framework for Objective 2

Constraints Monitoring Framework

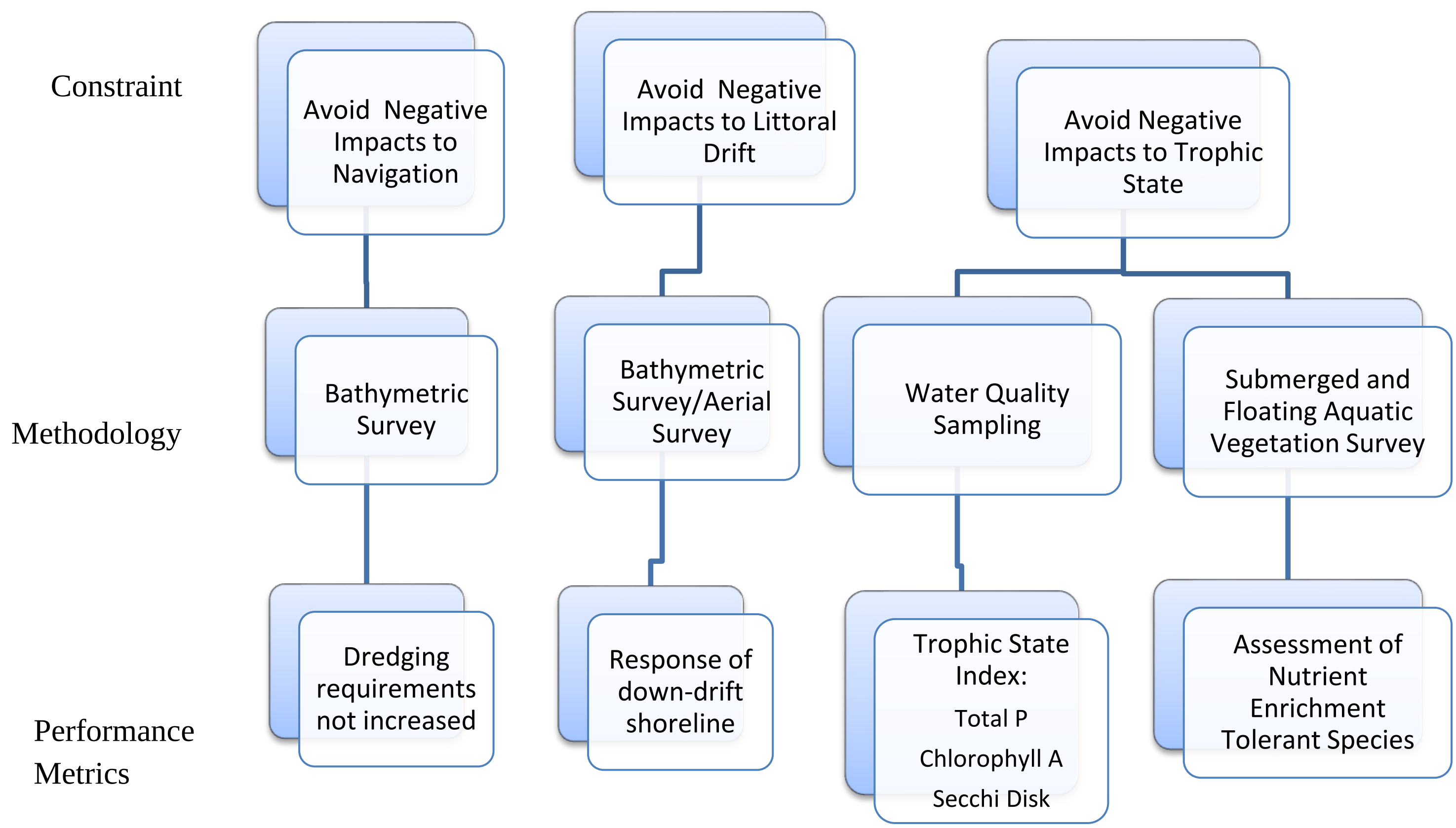


Figure 4. Monitoring Framework for Constraints

1.5 2016 Construction Progress

Implementation of the Braddock Bay Ecosystem Restoration project began in winter of 2016 with the excavation of approximately seven acres of channels and potholes within the existing marsh. Excavation began in January and concluded in March of 2016. Once completed, channel and pothole benches and habitat mounds were seeded with native seed mixes. Plugs of native wetland plants were planted in June of 2016. Cattail in the invasive species areas was mechanically removed in late July and treated chemically in late September. Phragmites stands were treated in late September and then removed mechanically in late October. Construction of the barrier beach began in August (Figure 6). Placement of the stone portions of the barrier beach were completed by December 2016. Additional work for 2017 will include sand placement on the barrier beach, installing lives stakes and plugs on the barrier beach, additional treatment of cattail and phragmites, and construction of a 2.7 acre of emergent marsh within Braddock Bay.

Figure 5. Pothole excavated during winter 2016. Photo take August 8, 2016.

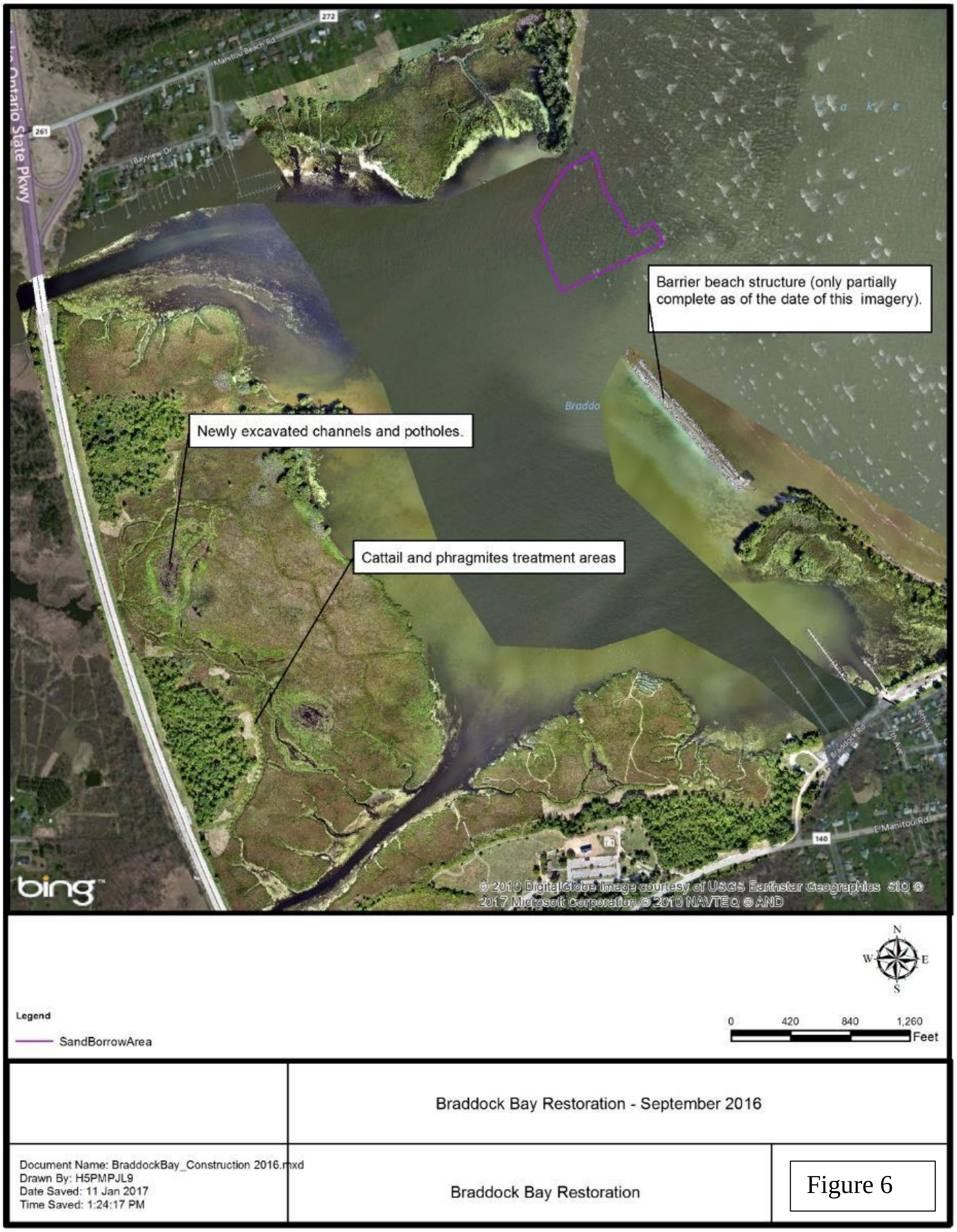


Figure 6. Braddock Bay Restoration, September 2016

2.0 Vegetation Monitoring

2.1 Emergent Marsh Monitoring

The emergent vegetative community in the areas of restoration are monitored to determine if project measures have been successful at restoring wetland and habitat diversity at Braddock Bay (Objective 1). Data collected regarding invasive species presence and absence will also help in determining if the project has adequately avoided the constraint of spreading invasive species (Constraint 4).

2.1.1 2016 Data Collection

Vegetation data was collected by SUNY Brockport between the days of 19 July 2016 and 15 August 2016, approximately four months after the completion of channel and pothole excavation. The full sampling methods and results can be found in (Appendix B). Only the data pertinent to the ecological performance criteria will be presented here.

2.1.2 Results

FQAI: Vegetation data from 372 quadrats (214 channel, 128 pothole, and 30 control) collected from 30 transects were compared to estimate the quality of the existing habitat. The Floristic Quality Assessment Index (FQAI) was used to evaluate the nativeness of an area based on the plant species present. Areas with a higher FQAI score are considered to be of higher quality than areas of lower FQAI. This index is based on coefficients of conservation (C-scores) that are assigned to plants in a given region. A C-score of 0 indicates non-native taxa with a widened range of tolerance in terms of environmental limits, with a score of 10 being a very specialized, narrow range of limits that the specific plant species can handle. C-scores in this assessment were based off the New York State preliminary C-score list (http://www.neiwpcc.org/nebawwg/fqaresources.asp).

To calculate average C-scores and FQAI, all data from different zones was combined to create pothole species list, a channel species list, and a control species list. Mean C-scores and FQAI were calculated for these combined list. In 2016, channels had a higher FQAI score than potholes and control plots with FQAI scores of 30.76, 27.02, and 20.43 respectively (Table 1). Native species richness was 57 in channel transects, 44 in pothole transects, and 23 in control transects. This initial survey suggests that vegetative communities in restored areas are of higher quality than those of unrestored (control) plots within Braddock Bay. Additional monitoring will be necessary to determine if these trends continue into future years.

Previously, FQAI at Braddock Bay pre-restoration was estimated at 17.8 using the Michigan FQAI (USACE, 2014). Current calculations use an updated set of C-Scores, and an average score for control plots and so are not comparable to the 2013 FQAI. The average FQAI of control quadrats should be used as a baseline for comparing the improved suitability of restored areas.

Table 1. 2016 Results of Vegetation Surveys by zone type

2016 Vegetation Survey by zone type			
	Control (n =30)	Channel (n=184)	Potholes (n=128)
Total # of Species	27	69	52
# of Native Species	23	57	44
Mean C	3.6	3.3	3.4
FQAI	**20.4**	**30.7**	**27.0**
% natives	85%	83%	85%

Percent Vegetative Cover: Percent vegetative cover was estimated during vegetation surveys along transects. The primary interest in this data is understanding if robust emergent and sedge grass meadow communities have established on pothole benches and habitat mounds respectively. The target percent cover is 80% for emergent vegetation and sedge grass meadow areas. The average percent covers on habitat mounds, channel benches, or pothole benches did not achieve this goal (Table 2). The average coverage of emergent vegetation on channel benches was 66% and 69% for shallow and intermediate benches respectively. Average percent cover on pothole benches was 48%. Average percent cover of sedge grass meadow communities on habitat mounds was 63%. For all locations, the variability of percent cover between survey locations was very large. Although the target percent cover was not met, further recruitment and community establishment is anticipated in 2017, therefore no adaptive management measures are recommended this time.

Table 2. Vegetation Survey Percent Cover

2016 Vegetation Survey Percent Cover							
CHANNEL TRANSECTS						POTHOLE TRANSECTS	
Habitat Mounds (Sedge-Grass)		**Shallow Bench (emergent)**		**Int. Bench (emergent)**		**Bench (emergent)**	
Average	Range	Average	Range	Average	Range	Average	Range
63%	10%-100%	66%	30%-100%	69%	25%-100%	48%	<5%-100%

Invasive Species Cover: The coverage of invasive species was noted during vegetation surveys.

In restored channel transects, *Lythrum salicaria* and *Typha x glauca* were dominant invasive species on habitat mounds adjacent to channels averaging 12.5% and 11.6% cover. *Typha glauca* and *Hydrocharis morsus-ranae* dominated channel benches with an average of 48.9% and 37.1 % respectively. By comparison, the average percent coverage of *Typha x glauca* in control plots was 51.7%.

2.1.3 Performance Criteria and Adaptive Management

The ecologic success criteria related to this component of adaptive management are:

1. Increase in quality (FQAI) of wetland habitat

2. Cover of emergent species > 80% of channel and pothole benches; cover of sedge grass meadow species >80% on habitat mounds.

3. Invasive species cover = 0% *Phragmites,* < 50% *Typha,* , <10% Other.

FQAI scores of restored channels and pothole areas, 30.8 and 27.0 respectively, are higher than control areas which scored 20.4. This suggests that restoration efforts have improved the quality of emergent wetlands in Braddock bay. The percent cover on emergent benches and habitat mounds did not achieve the target percent cover of 80%; however, additional establishment is anticipated in 2017. The coverage of *Typha x glauca* and *Phragmites* in restored areas was less than predetermined criteria (50% and 0% respectively). Other invasive species, *Lythrum salicaria* and *Hydrocharis morsus-ranae,* exceeded the predetermined criteria of 10% for other invasive species and were prevalent on habitat mounds and within channels, respectively.

Preliminary monitoring results indicate that restoration efforts have slightly improved the diversity of the vegetation community; however, this monitoring data only represents conditions during the first growing season following wetland excavation. Comparison of data from subsequent years will be necessary to determine if project objectives related to increasing habitat suitability have been achieved.

Lythrum salicaria and *Hydrocharis morsus-ranae* were both found to have been prevalent in habitat mounds and channels respectively. It is recommended that these species be given special attention in future years to ensure they do not negatively impact habitat suitability.

It is recommended the vegetation monitoring be continued in 2017 and again within 3-5 years to determine the establishment of native vegetation communities and to track invasive species.

2.2 Submerged Aquatic Vegetation and Floating Aquatic Vegetation Beds Monitoring

The submerged aquatic vegetation (SAV) and floating aquatic vegetation communities at Braddock Bay were monitored to determine if project measures have been successful at restoring wetland and habitat diversity at Braddock Bay (Objective 1). Vegetation data will also be used to assess if changes in the trophic state of Braddock Bay are occurring (Constraint 2). Data collected regarding invasive species presence and absence will also help in determining if the project has adequately avoided the constraint of spreading invasive species (Constraint 4).

2.2.1 2016 Data Collection

Surveys of the aquatic vegetation community were conducted by USACE on 30 Aug 2016. This sampling occurred during construction of the restored barrier beach. Surveys were conducted using rake toss methods combined with acoustic sonar surveys. The Biobase® software was used to collect and interpret the acoustic sonar data.

Rake Toss Method - One hundred and three sample locations within Braddock Bay were sampled by rake toss method. Sample locations were laid out on a 75m grid in near shore areas and 150m grid in the center of the bay. At each sample location a double headed steel garden rake (14 in. width) attached to a rope was tossed into the water at a distance of approximately 10' from the vessel and dragged along the substrate during retrieval. All species attached to the rake upon retrieval were recorded and characterized by density using the following classification (1 – sparse, retrieval suggests presence of one plant; 2 - moderate, retrieval suggests presence of multiple plants; 3 – dense, retrieval suggests presence of dense aquatic bed).

Acoustic Sonar and Biobase – Hydroacoustic and global positioning system (GPS) data was collected using a Lowrance High Definition System (HDS) echosounder. The transducer was oriented vertically and mounted to the boat stern approximately 1.25 feet below the surface. We used the Navico BioBase settings recommended for the Lowrance unit (BioBase, 2014). The acoustic and GPS signals were logged to data storage cards in sl2 format. Data collected were analyzed with ciBioBase servers. After ciBioBase processed the data, ciBioBase generated a report for each site containing vegetation, bathymetry and substrate. Comma-separated values (CSV) files for each map layer were downloaded from the ciBioBase's website and maps were created in ArcGIS. Exported data included record number, latitude, longitude, bottom depth and biovolume (defined as percent of the water column taken up by vegetation) substrate hardness. Bottom depths and vegetation biovolume estimates were corrected for transducer depth. At some locations near the shore, shallow depths and heavy aquatic vegetation growth prevented retrieval of hydroacoustic data needed to generate maps. Maps were corrected after sampling for these areas based on field notes and survey data.

2.2.2 Results

As this sampling occurred during the construction of the barrier beach, the survey results provide baseline data for which to compare future data for the purposes of evaluating the condition of the Braddock Bay aquatic vegetation community. The results of the acoustic monitoring are reflected in Figure 7.

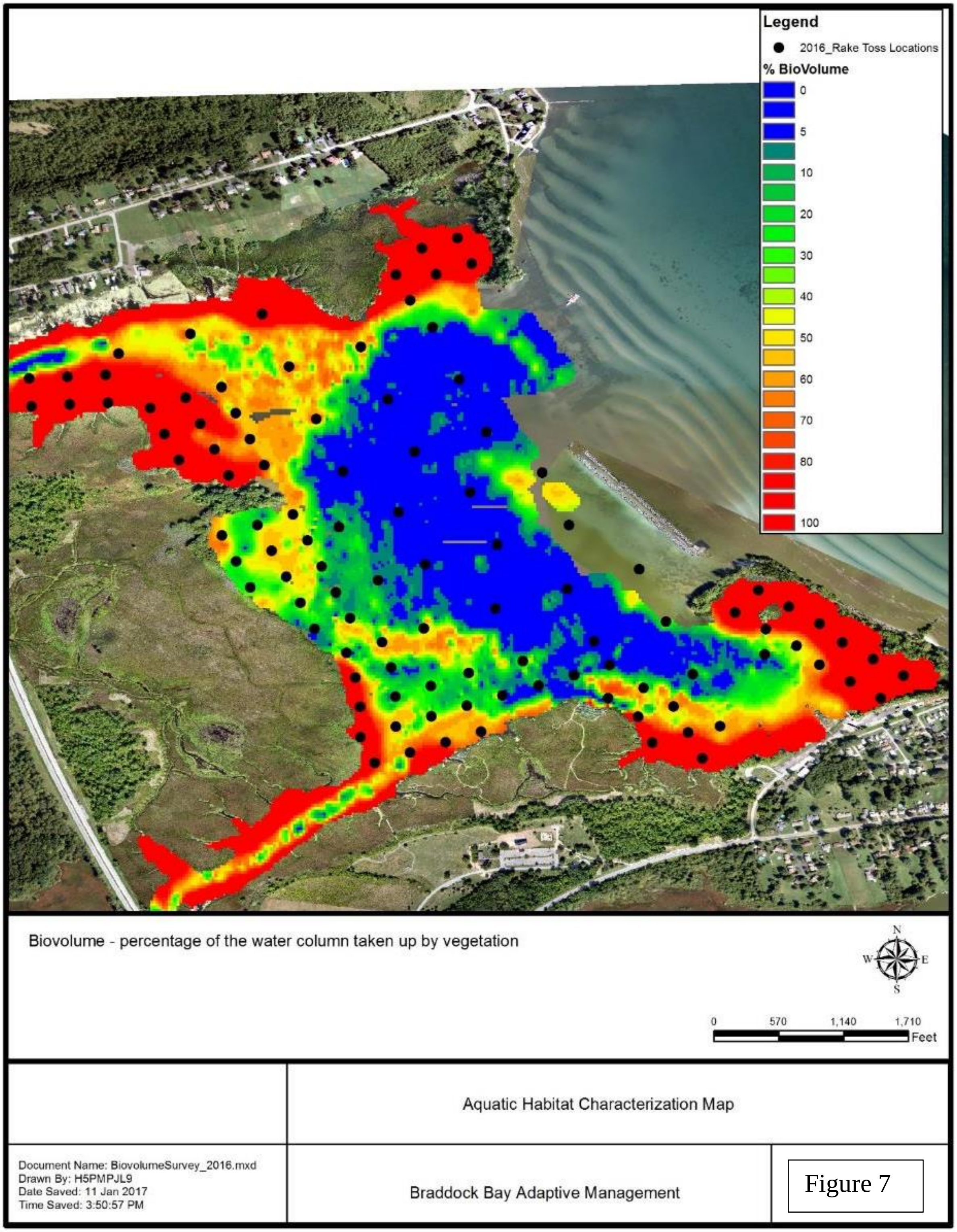


Figure 7. Braddock Bay Aquatic Habitat Delineation, August 2016

A total of 14 species of aquatic vascular plants were recorded in Braddock Bay during the 2016 survey. Of the 104 sample points, 18 resulted in no return and are considered to be un-vegetated substrate. Thirteen of the species were native to the region. Eurasian milfoil (*Myriophyllum spicatum*) and brittle water naiad (*Najas minor*) were the only non-native species recorded during rake tosses. A rosette of water chestnut was also observed in the area north of the Braddock Bay marina, however, this was not recorded in any rake toss sampling. The most widespread species was American water celery (*Vallisneria americana)* and was found in 64% of all plots sampled and was a dominant species in 56% of vegetated plots. Other common native species included *Elodea canadensis* and *Ceratophyllum demursum* occurring in 28% and 23% of sample points respectively. The two observed invasive species, *Myriophyllum spicatum* and *Najas minor*, were both observed in 28% of sample locations. These species were dominant in 15% and 22% of vegetated sample points, respectively (Figure 7). The Floristic Quality Assessment Index (FQAI) score was calculated using the NY list of Coefficients of Conservatism (http://www.neiwpcc.org/nebawwg/fqaresources.asp). The FQAI score for the aquatic habitat in segments 4 and 5 of Braddock Bay was 13.90 in 2016, a slight increase from the 2013 FQAI score of 11.3. These segments are considered to be the most likely to be affected by the barrier beach. As the 2016 data included a more exhaustive sampling, it is considered to provide a better baseline for which to compare future years.

The dominance of nutrient enrichment tolerant species will be used to determine if the aquatic vegetation communities of Braddock Bay are shifting toward a more eutrophic state. Nutrient enrichment tolerant species, as defined by the Great Lakes Coastal Wetland Monitoring Plan (2008), are identified in (Figure 8) below.

Stress	Species
Nutrient Enrichment	*Ceratophyllum demersum*
	Elodea canadensis
	Lemna minor
	Myriophyllum spicatum
	Potamogeton crispus
	Potamogeton pectinatus
	Algae

Figure 8. Nutrient Enrichment Tolerant Species (pg. 48, Great Lakes Coastal Wetlands Monitoring Plan, 2008

Of the 14 species observed during the aquatic vegetation survey, four were considered to be nutrient enrichment tolerant species: *E. canadensis, M. spicatum, C. demsursum, and Stuckenia pectinatus (Potamogeton pectinatus).* Nutrient enrichment tolerant species were observed in 35% of the 86 vegetated sample points.

This data on the extent and coverage of aquatic vegetation is a usefull baseline for tracking the response of aquatic vegetation in Braddock Bay to the construction of the barrier beach. However, the influence of lake level management and nutrient loading to the bay on aquatic vegetation will also need to be considered.

Table 3. 2016 Aquatic Vegetation Survey Species List and Dominance

2016 Species Observed	# of times observed	% of all sample points	% of vegetated sample points	% of veg. plots in which species is dominant
Vallisneria americana	67	64%	78%	56%
Elodea canadensis	29	28%	34%	19%
Myriophyllum spicatum*	29	28%	34%	15%
Najas minor*	29	28%	34%	22%
Ceratophyllum demersum	24	23%	28%	15%
Heterantehra dubia	11	11%	13%	-
Myriophyllum verticillatum	9	9%	10%	-
Najas flexilis	5	5%	6%	-
Nymphea odorata	4	4%	5%	-
Lemna truscala	3	3%	3%	-
Chara sp.	2	2%	2%	-
Potamogeton richardsonii	2	2%	2%	-
Potamogeton robinnsii	2	2%	2%	-
Potamogeton pusillus	1	1%	1%	-
Stuckenia pectinata	1	1%	1%	-
Species richness	15			
Total Sample Points	104			
Sample points without Vegetation	18	17%		
Points dominated by a nutrient enrichment tolerant species			30	35%
*** non-native species**		**Nutrient Enrichment Tolerant Species**		

2.2.3 Performance Criteria and Adaptive Management

As this survey was completed before the completion of the barrier beach, this data will provide a useful baseline for tracking the changes in the submerged aquatic vegetation community. This survey indicates that V. americana is an important species of the aquatic community of Braddock Bay. Furthermore, the high occurrence of nutrient enrichment tolerant species indicate the bay is currently in a eutrophic state, as is consistent with water quality data.

The extent and diversity of the aquatic communities of Braddock Bay may change as a result of the reduced wave energy and turbidity in the bay. Expansion of aquatic beds has potential to increase the area of aquatic habitat. Changes in the dominance of nutrient enrichment tolerant species could provide evidence of a trend towards or away from further eutrophication. The response of aquatic vegetation to changing conditions of nutrients and wave energy is anticipated to take several growing seasons. Therefore, sampling could occur every other year after 2017.

2.3 Fish and Wildlife Monitoring

Surveys of fish, waterbirds, mammals and amphibian species were completed to determine if project measures have been successful at improving the suitability of the Braddock Bay wetland for fish and wildlife (Objective 1).

2.3.1 2016 Data Collection

Bird and Anuran Monitoring – The bird and amphibian community in Braddock Bay was surveyed during the Spring of 2016. Bird surveys were conducted weekly between May 25, 2016 and June 27, 2016. Anuran monitoring surveys were conducted weekly between April 18, 2016 and July 13, 2016. Surveys were conducted at three locations (Figure 9) throughout the bay during three visits using traditional Marsh Monitoring Protocol (MMP) (BSC, 2000). Surveyors recorded all anuran species detected during 3 minute long surveys. Call codes were used as an index of abundance. At each sample location, the bird community was surveyed for 15 minutes long consisting of 5 minutes of passive listening, 5 minutes of marsh bird song audio playback to entice calls, and a final 5 minutes of passive listening; all birds detected aurally and visually were recorded. For additional information see Appendix 2.

Fish Surveys – The fish community in newly-created potholes and previously existing shallow water areas of Braddock Bay were surveyed from October 7th to October 16th of 2016. Survey crews used both large mesh (6.25mm) and small mesh (2.4mm) nets evenly in both habitats to balance out the biases present in both mesh sizes. Each mesh size was fished for four net-nights in each habitat, for a total of eight net-nights of fishing per habitat and 16 net-nights overall. Figure 10 shows the net locations in the newly-created and control zones. Nets were placed in water between 0.5 and 1.0m deep for approximately 18-24 hours. All species encountered, both fish and non-fish, were identified, aged as either “Young of Year (YOY)” or “Other”, and counted the following morning. All fish were returned back to the water and the net was re-set for the following night. For additional information see Appendix 2.

Figure 9. 2016 Amphibian and Bird Count Locations

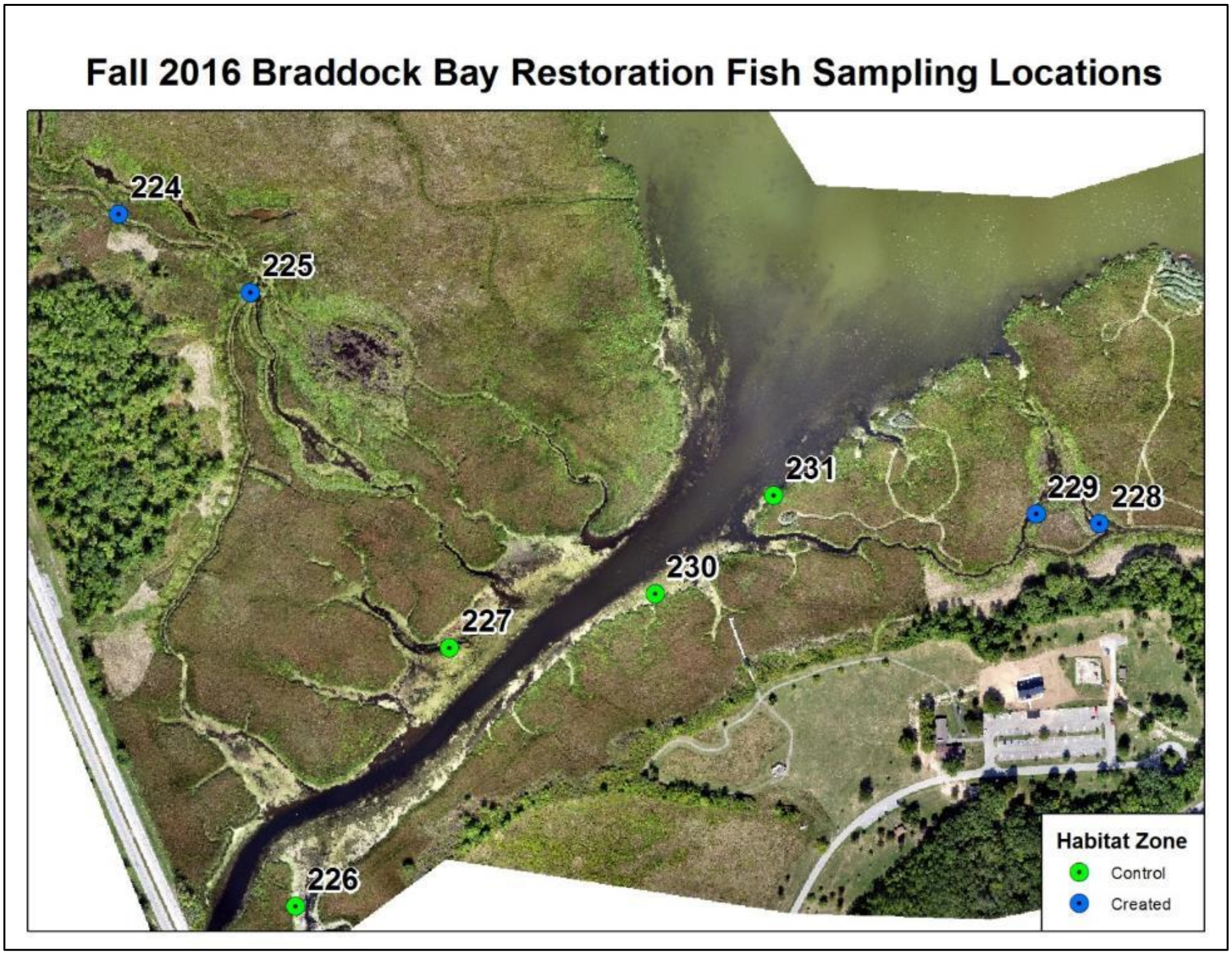


Figure 10. 2016 Fish Survey Locations

2.3.2 Results

(1) Amphibian Monitoring

Six anuran species were detected during the three surveys in spring of 2016 (Table 4). Only at sample location 3 were all species recorded. Spring peepers (*Pseudacris crucifer*) were recorded having the highest call count in all three sample locations. This species richness is similar to survey results from 2016 surveys of Buck pond and Buttonwood Creek (SUNY Brockport, 2016) Pre-restoration surveys from Braddock Bay conducted in 2013 only observed 4 species. Gray tree frog and American toad were not observed in 2013 (Table 5).

Table 4. 2016 Anuran Survey Results

	Braddock 1	Braddock 2	Braddock 3	Grand Total
American Bullfrog	1	2	1	2
American Toad	1			1
Green Frog	2	2	2	2
Gray Tree frog	2	2		2
Northern Leopard Frog	2		2	2
Spring Peeper	3	3	3	3

*Data reported by call code (1 = calls not simultaneous, 2 = Some call simultaneous, 3 = full chorus)

Table 5. Anuran Call Intensity

Anuran Call Intensity	2013	2016
American Bull Frog	1	1
American Toad	-	1
Green Frog	2	2
Gray Tree frog	-	2
Northern Leopard Frog	2	2
Spring Peeper	3	3
This data represents the highest call intensity recorded during sampling at Braddock Bay location 1.		

(2) Bird Monitoring

A total of 28 and 25 bird species were detected in survey stations 1 and 2, the survey locations that cover cattail treatment, channel, and pothole portions of the restoration. Survey station 3, the station furthest away from the restoration areas had 27 species present (Figure 6). Red Winged Blackbird (*Agelaius phoeniceus*) was the most commonly detected species across all point with a total of 100 individuals detected. Barn swallow (*Hirundo rustica*), Marsh Wren (*Cistothorus palustris*), ring-billed gull (*Larus delawarensis*), and Tree Swallow (*Tachycineta bicolor*) were the next four most commonly detected species. Three invasive bird species, mute swan (*Cygnus olor*), European starling (*Sturnus vulgaris*), and double crested cormorant (*Phalacrocorax auritus*), were detected in the surveys and were mostly observed at station 3 that has the best view of open water. Few marsh-nesting obligate focal species were detected, with only two least bittern (*Ixobrychus exilis*), one American bittern (*Botaurus lentignosus*), and one American coot (*Fulica americana*) detected across all surveys and locations. Both least bitterns were detected at station 3, away from the marsh restoration activities, while the single American Coot and American Bittern were detected at survey station 2, close to the restoration activities. For additional information see Appendix 2.

Table 6. 2016 Avian Survey Results

Species	Braddock 1	Braddock 2	Braddock 3	Total Abundance
Red-Winged Blackbird*	39	39	22	100
Barn Swallow	29	13	12	54
Marsh Wren*	30	7	17	54
Ring-Billed Gull	19	29	5	53
Tree Swallow	23	11	18	52
Swamp Sparrow*	13	21	2	36
Yellow Warbler*	6	8	11	25
Canada Goose	19	5		24
Common Yellowthroat*	10	7	3	20
Song Sparrow *	6	10	4	20
Mute Swan*	2		16	18
Wilson's Flycatcher	7	6	1	14
Common Grackle	2	3	7	12
Mallard	9		3	12
European Starling	6		4	10
Caspian Tern	3		6	9
American Robin*	4	2	2	8
American Goldfinch*		6	1	7
Warbling Vireo	2		5	7
Gray Catbird*	1	1	4	6
Purple Martin		3	3	6
Cedar Waxwing		1	4	5
Northern Cardinal	3		2	5
Bank Swallow	3			3
Double-Crested Cormorant	1		2	3
Eastern Kingbird*	3			3
Osprey		3		3
Bald Eagle	1	1		2
Great Blue Heron		1	1	2
Killdeer		2		2
Least Bittern			2	2
American Bittern		1		1
American Coot		1		1
American Kestrel		1		1
Baltimore Oriole			1	1
Bobolink	1			1
Great-crested Flycatcher		1		1
Great Egret			1	1
Mourning Dove	1			1
Northern Rough-Winged Swallow	1			1
Red-Bellied Woodpecker	1			1
Grand Total	**245**	**183**	**159**	**587**
Native Species Richness	**25**	**25**	**24**	
*SPECIES ALSO RECORDED IN 2013 Non-native/invasive				

(3) Fish Monitoring

The control habitats, pre-existing bodies of water that were not modified by the restoration, yielded nearly three times as many fish as the newly-created habitat, with 1282 and 445 fish in the control and created habitats, respectively (Table 7). The age class breakdowns were nearly identical in the control and created habitat, with YOY fish making up 12.1% and 13.3% of the community, respectively. The majority of YOY fish in both habitats were bluegill sunfish (*Lepomis macrochirus*) and pumpkinseed sunfish (*Lepomis gibbosus*), who combined made up greater than 95% of the YOY catch in both habitats. The next most prevalent YOY fish was central mudminnow (*Umbra limi*), with 16 YOY fish in the newly created habitat. As a whole, bluegill and pumpkinseed sunfish were the most prevalent species caught across both habitats. Two northern pike (*Esox lucius*) "other" age class fish were caught in the newly created habitats; however, no YOY pike were caught in either habitat. Native fish species richness was slightly higher in the created habitat than in the control areas, with 10 and 9 species respectively.

At this point, it is not clear why the newly-created habitats contained roughly one-third of the fish as the control habitats. The possibilities include the fact that the control zone was more riverine while the created potholes are semi-isolated pools; the fact that the newly created potholes do not have a fully-developed submersed aquatic vegetation community yet; or because the severely dry summer caused the potholes to be shallower than anticipated and resulted in a low dissolved oxygen environment.

Table 7. Fish species caught in the control and newly-created pothole habitats in fall 2016

		Control		**Created Habitat**	
Species		**Other**	**YOY**	**Other**	**YOY**
Pumpkinseed Sunfish		83	567	1	323
Bluegill Sunfish		8	552	48	608
Yellow Perch		36	2	38	0
Central Mudminnow		0	0	18	16
Brown Bullhead		8	0	13	0
Largemouth Bass		4	1	12	0
Round Goby*		8	0	0	0
Bowfin		2	0	5	0
Tadpole Madtom		3	0	3	0
Rock Bass		0	5	0	0
Golden Shiner		3	0	0	0
Green Sunfish		0	0	2	0
Northern Pike		0	0	2	0
Common Carp*		0	0	1	0
Grand Total		**155**	**1127**	**143**	**947**
Native Fish Richness		**9**		**10**	

*Invasive Species

2.3.3 Performance Criteria and Adaptive management

The ecologic success criteria for related to this component of adaptive management are:

1. Increase in species richness of water birds
2. Increase in species richness of amphibians
3. Increase in species richness and abundance of YOY fish

Bird and anuran data from 2013 surveys (Brockport, 2013) at Braddock Bay provide a baseline for comparing post restoration samples. These samples were collected using similar methods; however, surveys were conducted less frequency in 2013 and also only conducted from one of the locations sampled in 2016, "Braddock 1" in the vicinity of the restoration near the eastern marsh

The number of bird species recorded at location "Braddock 1" increased from 14 in 2013 (Brockport 2013) to 27 in 2016. It is uncertain if the increase richness is due directly to the restoration work or the increased sampling frequency in 2016. The recordings of marsh nesting obligates (American bittern and American coot) recorded at "Braddock 2" may suggest increased habitat suitability as a result of restoration work. Additional monitoring in 2017 will help determine this.

The number of anuran species recorded increased from four in 2013 to six in 2016 (Table 5. For all species observed in 2013 and 2016, there was no change in the intensity of the call code. It is uncertain if the increase richness is due directly to the restoration work that was completed in winter of 2016 or just a relic of the increased sampling frequency in 2016. This preliminary data suggest that habitat suitability may have improved due to restoration activities. Additional monitoring in 2017 will help determine this.

Ten native fish species were recorded in restored channels and potholes while only 9 were recorded in control areas in Braddock Bay. Northern pike, a target species of restoration, was among the species recorded in restored areas that was not recorded in-control sites. The low number may be due to the fall timing of the sampling. Unfortunately, no young of year pike were recorded. The increased species richness and the presence of northern pike in the restored areas are positive signs that the restoration is achieving its objectives.

2.4 Wetland Erosion Monitoring

Aerial imagery will be used to monitor the central wetland for the purposed of determining if restoration measures have been successful at protecting the central wetland of Braddock Bay from erosion (Objective 2).

2.4.1 2016 Data Collection

Aerial imagery for Braddock Bay was collected using an unmanned aerial vehicle (Appendix 4). This information was collected on Sept 13 – 15, 2016 as construction was occurring. Both RGB and near infrared images were collected.

2.4.2 Results

As these images were collected prior to the completion of the barrier beach, they represent a baseline for which to assess future erosion. It is apparent from comparison to the 2009 shoreline delineation that erosion of the central wetland has persisted over the past seven years (Figure 11). In some places approximately 100 feet of emergent wetland has been lost. Based on analysis of this aerial imagery, approximately 3.2 acres of emergent wetland have been lost since 2009, equating to a rate of 3.2 acres per year.

2.4.3 Performance Criteria and Adaptive Management

Erosion over Braddock Bay emergent wetlands averaged a loss of 1.19 acres per year over the period of 1961 to 2009. It was projected that without a project, the erosion rate would continue at approximately 0.42 acres per year. The erosion estimates over the past seven years (pre-barrier beach restoration) are consistent with the projected erosion rate under the without-project condition. Additional imagery collected, over several years following barrier beach restoration will be needed to determine if the restored barrier has reduced erosion of Braddock Bay emergent wetlands. Aerial imagery should be collected in late summer-fall of 2017 and analyzed to characterize post restoration erosion rates. If budgetary constraints do not allow for collection of new aerial imagery, it may be possible to utilize aerial imagery collected by other groups such as The New York State Natural Heritage Program

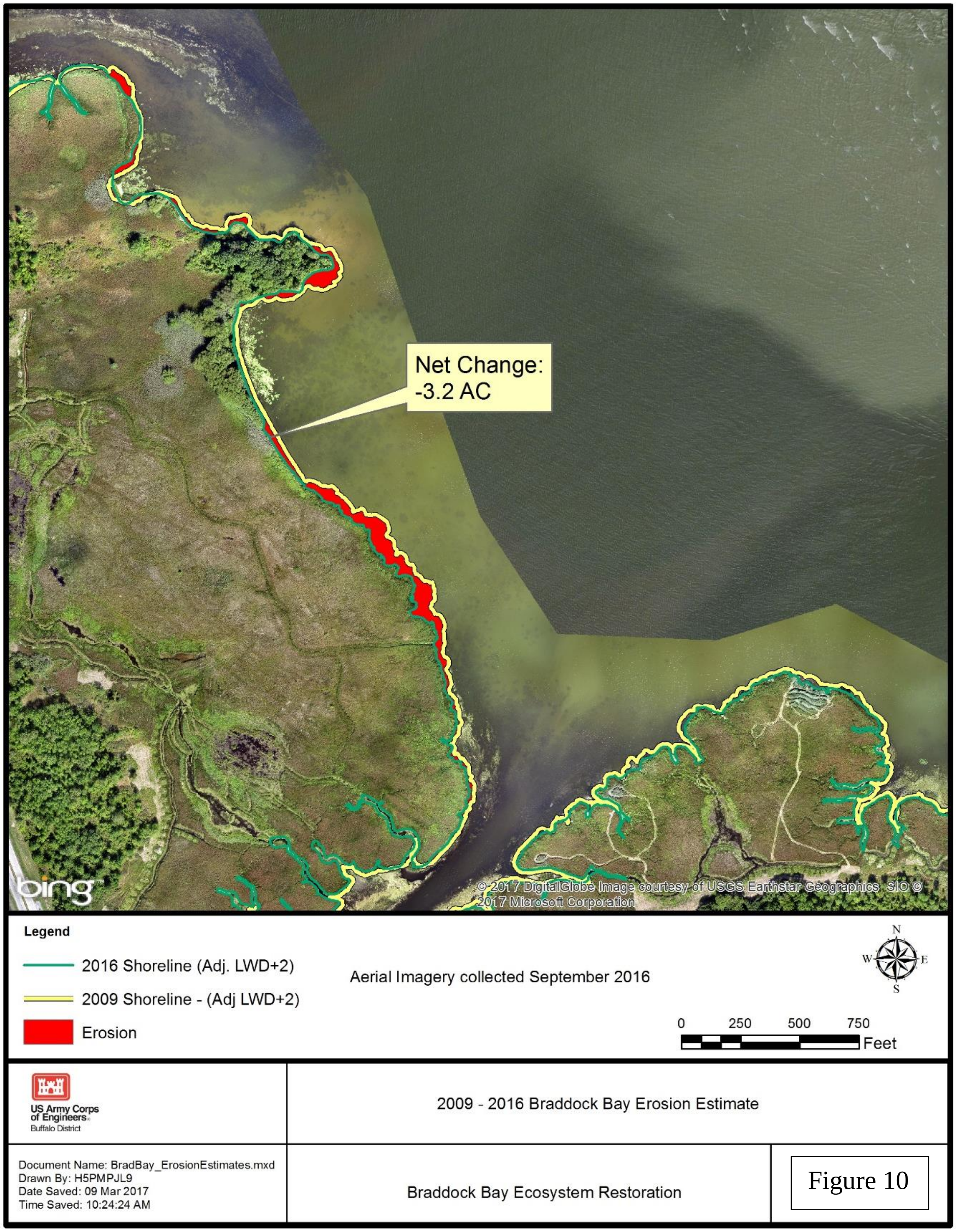


Figure 11. 2009 to 2016 Braddock Bay Erosion Estimate

2.5 Navigation Monitoring

The bathymetry of the Braddock Bay navigation channel will be monitored to determine if proposed restoration measures have successfully avoided disruptions to the navigability of the bay (Constraint 1).

2.5.1 2016 Data Collection

The barrier beach or navigation channel was not completed during 2016 and thus as built bathymetry was not collected. This data will be collected in spring of 2017 and in subsequent years.

2.5.2 Performance Criteria and Adaptive Management

This will be assessed when 2017 bathymetry data is available.

2.6 Littoral Sediment Monitoring

The net deposition/erosion of littoral sediment will be monitored to determine if proposed restoration measures have successfully avoided disruptions to the local littoral drift system (Constraint 3). This will be measured through aerial photography and bathymetric surveying.

2.6.1 2016 Data Collection

Aerial imagery for Braddock Bay was collected using an unmanned aerial vehicle (Appendix 5). This information was collected on Sept 13 – 15, 2016 as construction was occurring. Both RGB and near infrared images were collected. Post construction bathymetry data will be collected in spring of 2017. Together this information will serve as the baseline for littoral sediment monitoring.

2.6.1 Performance Criteria and Adaptive Management

Performance criteria and adaptive management recommendations will be assessed when 2017 data is available.

2.7 Trophic State Monitoring

Water quality parameters of Braddock Bay will be monitored to determine if the trophic state of Braddock Bay has been negatively impacted by project activities (Constraint 2).

2.7.1 2015 and 2016 Data Collection

To determine the baseline conditions of Braddock Bay, water samples were collected at five locations within Braddock Bay (SG2, SG3, SG4, SG5a, and SG5b), at the two main tributary inputs to the bay (Salmon Creek (SC) and Buttonwood Creek (BW)), and at a near shore location just outside the bay in Lake Ontario (Figure 12). Samples were collected from June to September four times during 2015 and six times during 2016. The last two sampling events of 2016, however, were collect during barrier construction and are not included in this report as baseline samples. Samples collected during construction are used for comparison and to establish relationships between variables within Braddock Bay. During 2015, some sampling events were influenced by storm events. During 2016, samples were not collected within five days of a major storm event, which was taken to mean a rain event of 0.5 inches within a 24 hour period. 2016 was a drought year. For both years when possible, sample events were spaced at least 15 days apart. During both years, water samples were collected 1 to 1.5 ft below the water's surface at four locations around the sampling site coordinates. During both years, multi-probe sensor measurements and Secchi disc depth were collected at the sampling point. During 2015, water samples were put on ice and shipped to an analytical lab for processing (USACE 2016). During 2016, water samples for total nutrients, chlorophyll, suspended solids, and turbidity were stored on ice and filtered or digested within 36 hours of collection. During 2016, dissolved nutrient samples were filtered through a 0.45 µm polycarbonate membrane filter on site, stored on ice for transport back to the lab and analyzed fully within 36 hours. For additional detail see Appendix 2.

2.7.2 Results

Baseline conditions for Braddock Bay, Lake Ontario, and Tributaries for the study period (2015 – 2016) are listed in Table 8. The 95% confidence interval was used as the estimate for the normal range for baseline conditions prior to barrier construction. This provides a conservative estimate of normal conditions in Braddock Bay and statistically reduces the impact of extreme events or outlier measurements on baseline conditions in the ecosystem. For Braddock Bay, mean and confidence intervals for ecosystem target criteria were 0.014 mg/L (0.003 to 0.131) for PO4, 0.102 mg/L (0.033 to 0.200) for TP, 0.050 mg/L (0.013 to 0.213) for NH4, 0.136 mg/L (0.000 to 0.704) for NO2NO3, 1.123 mg/L (0.573 to 1.800) for TKN, 41.6 µg/L (11.5 to 86.8) for CHL, 1.9 ft (1.0 to 3.4) for Secchi depth, and 67 (61 to 75) for TSI. Ecosystem target criteria were exceeded 86.1%, 80%, 85%, and 94.4% of the time at sites within Braddock Bay for Secchi depth, TP, chlorophyll a, and TSI, respectively.

Water quality conditions were much better at the Lake Ontario site than in Braddock Bay and Tributaries (Table 8). Tributary inputs to Braddock Bay were nutrient rich, especially with respect to PO4. Tributaries were generally free of phytoplankton blooms and relatively clear. The Tributaries always loaded PO4 but often had levels of dissolved inorganic nitrogen (NO2NO3 + NH4) near detection limits. Hence, the Tributary complexes of Braddock Bay are significant source of phosphorus to the bay but typically buffer against nitrogen contaminants entering the bay. Interesting, Lake Ontario has higher levels of NO2NO3 on average than Tributaries and could act as a nitrogen source to Braddock Bay.

Despite evidence of water exchange between the bay and lake, the poor water quality conditions seem to be isolated to Braddock Bay and rarely caused undesirable conditions in near shore Lake Ontario. Lake Ontario was nitrate and nitrite rich relative to the bay and the tributaries. The bay and tributaries were phosphorus and bound nitrogen rich relative to Lake Ontario. The tributaries were typically high in phosphate. Braddock Bay was relatively rich in phosphorus relative to nitrogen, suggesting conditions of nitrogen limitation might exist within the bay.

During 2015 phytoplankton blooms were not reported and the water appeared turbid due to sediment resuspension (USACE 2016). In contrast during 2016, Braddock Bay experienced a large phytoplankton bloom with little evidence of sediment resuspension. The water quality conditions during 2015 seem to be driven by sediment resuspension and tributary inputs. The water quality conditions during 2016, with low tributary flows, likely were controlled by internal nutrient cycling and perhaps exchange with Lake Ontario, which favored phytoplankton bloom development. Differences in correlations among water quality variables between years, suggest baseline conditions in 2015 were dictated largely by tributary inputs and sediment resuspension, while baseline conditions in 2016 (a drought year) were dictated by internal processes associated with a large phytoplankton bloom. In both years, CHL correlated negatively with PO4 but did not correlate with TP. During 2015, CHL did not correlate well with any other water quality parameters. In contrast, during 2016 CHL correlated strongly with TKN, Turbidity, and Secchi depth (Table 3; Fig. 4). These relationships suggest the phytoplankton bloom drove poor water clarity conditions in 2016 but less so in 2015. Given the high levels of phosphorus in 2016 and the strong correlation between CHL and TKN, it is likely that the phytoplankton bloom was nitrogen limited. These findings suggest that both nitrogen and phosphorus pollution are important to control in order to improve TSI in Braddock Bay.

Table 8. Summary water quality conditions (minimum, maximum, mean, and 95% confidence interval) for Lake Ontario, Braddock Bay, and its Tributaries for barrier pre-construction sampling events.

	min	max	mean	95% CI
Phosphate (PO4; mg/L)				
Lake Ontario	0.002	0.028	0.010	0.003 to 0.022
Braddock Bay	0.002	0.259	0.014	0.003 to 0.131
Tributaries	0.057	0.267	0.154	0.060 to 0.237
Total Phosphorus (TP; mg/L)				
Lake Ontario	0.006	0.022	0.009	0.006 to 0.018
Braddock Bay	0.030	0.284	0.102	0.033 to 0.200
Tributaries	0.140	0.330	0.201	0.140 to 0.297
Ammonia (NH4; g/L)				
Lake Ontario	0.010	0.047	0.030	0.015 to 0.043
Braddock Bay	0.011	0.300	0.050	0.013 to 0.213
Tributaries	0.017	0.310	0.071	0.020 to 0.243
Nitrate+Nitrite (NO2NO3; mg/L)				
Lake Ontario	0.000	1.700	0.311	0.000 to 1.217
Braddock Bay	0.000	2.400	0.136	0.000 to 0.704
Tributaries	0.000	1.500	0.142	0.000 to 0.668
Total Kjeldahl Nitrogen (TKN; mg/L)				
Lake Ontario	0.130	1.000	0.497	0.173 to 0.972
Braddock Bay	0.190	2.200	1.123	0.573 to 1.800
Tributaries	0.290	7.200	1.334	0.487 to 3.150
Chlorophyll a (CHL: µg/L)				
Lake Ontario	1.3	20.3	6.2	1.8 to 19.3
Braddock Bay	2.7	122.8	41.6	11.5 to 86.8
Tributaries	1.3	30.7	7.6	1.3 to 17.3
Secchi Disc Depth (ft)				
Lake Ontario	3.7	6.8	5.8	4.0 to 6.6
Braddock Bay	1.0	3.7	1.9	1.0 to 3.4
Tributaries	1.1	8.0	5.0	1.7 to 7.7
Trophic State Index (TSI)				
Lake Ontario	39	56	44	40 to 52
Braddock Bay	58	77	67	61 to 75

2.7.3 Performance Criteria and Adaptive Management

Ecosystem target criteria were exceeded 86.1%, 80%, 85%, and 94.4% of the time at sites within Braddock Bay for Secchi depth, TP, chlorophyll a, and TSI, respectively under baseline conditions. As a result, the predetermined ecologic criteria specified in the Braddock Bay

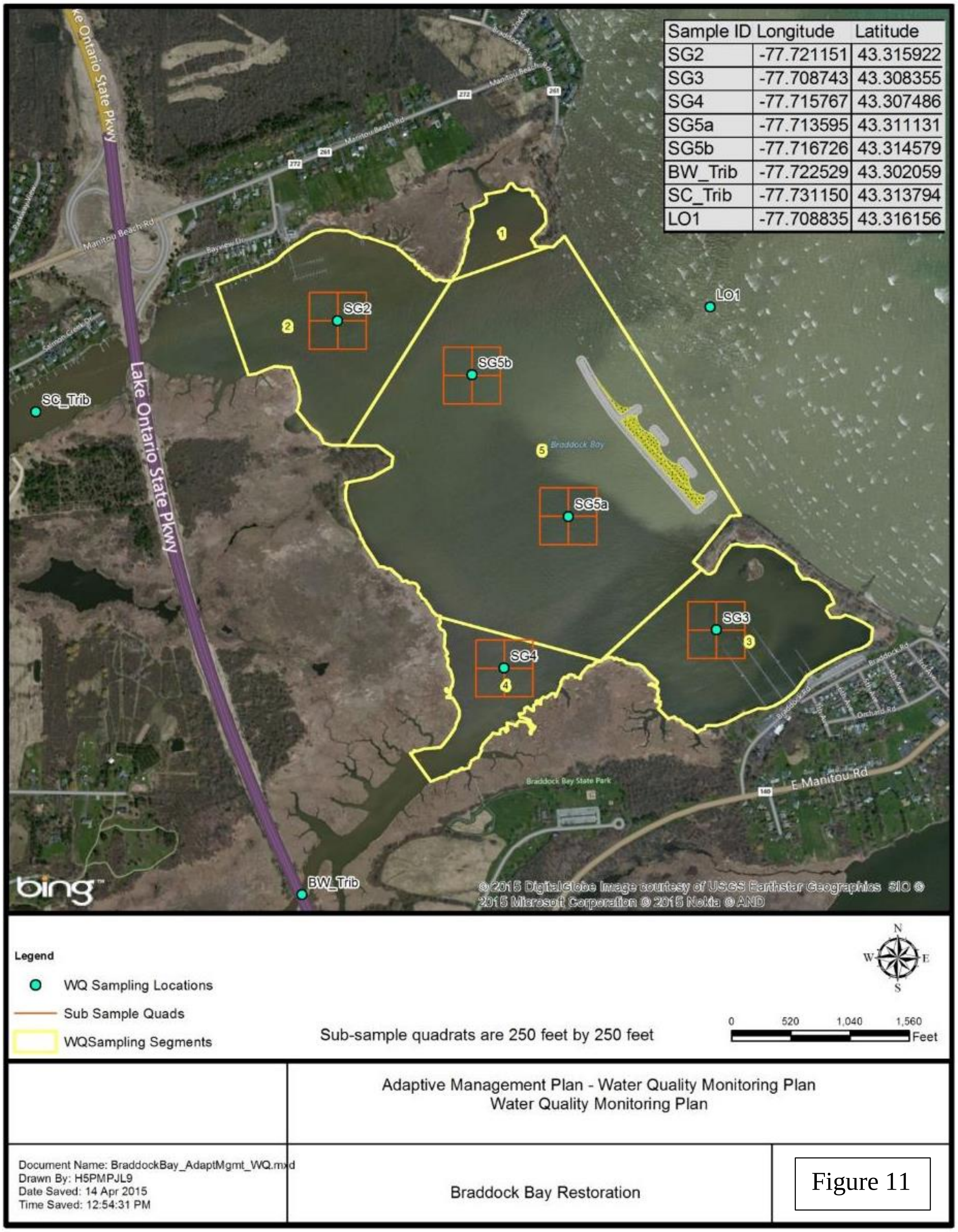
Adaptive Management plan does not appear suitable for determining if the trophic state of the bay has been negatively impacted by the proposed restoration project.

As recommended in the 2015 water quality monitoring report, determinations about the necessity of adaptive management actions related to water quality should be based on an analysis of the trends in TP and chlorophyll α data while also considering changes in the aquatic vegetation community. Increasing trends of TP and chlorophyll a concentrations with an observed shift in the aquatic vegetation community to a more eutrophic composition would be strong evidence that the trophic state of the Bay is shifting and adaptive management actions are necessary.

Additional sampling will continue through 2017.

2.1 Barrier Beach Monitoring

As the barrier beach was not completed in 2016, there was no need for a visual survey. This will be completed in 2017.



Sample ID	Longitude	Latitude
SG2	-77.721151	43.315922
SG3	-77.708743	43.308355
SG4	-77.715767	43.307486
SG5a	-77.713595	43.311131
SG5b	-77.716726	43.314579
BW_Trib	-77.722529	43.302059
SC_Trib	-77.731150	43.313794
LO1	-77.708835	43.316156

Figure 12. Water Quality Monitoring

3.0 Performance Criteria Summary

Table 9. Monitoring and Adaptive Management Plan

Objectives				
	Monitoring Methodology	Ecologic Success Criteria	2016 Results	Criteria Met
Wetland Habitat Diversity	Emergent Vegetation	$FQAI_{control}$= 20.4	$FQAI_{control}$= 20.4 $FQAI_{channels}$= 30.7 $FQAI_{potholes}$= 27.0	**Yes**
		% Cover >= 80% of emergent and sedge grass meadow.	% Cover = 48% – 69% benches 63% habitat mounds	**No.** Continue monitoring.
		% Invasive Cover = *0% Phragmites*, < 50% *Typha* species, <10% of other invasive species	% Phragmites Cover = *0%* *% Typha Cover = 48.9%* % other invasive species = 37.1%	**Partial Attainment.** Yes for Phragmites and Typha. No for European Frogbit.
	SAV and Floating Vegetation Survey – Rake and sample plots (Bay segments 2-5)	SAV FQAI increases	FQAI $baseline_{2016}$ = 13.9	Not evaluated in 2016.
Habitat Suitability	Fish surveys	Native fish species richness increase.	control = 9; restored areas = 10	**Yes,** species richness criteria met. Northern pike observed in restored areas.
		Abundance of YOY northern pike increase	No northern pike YOY recorded	**No**
	Bird Surveys	Bird Species Richness > $14_{(2013)}$	Restored areas = 27	**Yes**
	Amphibian Surveys	Amphibian species richness > $4_{(2013)}$	Amphibian species richness = 6	**Yes**
Reduce Erosion	Shoreline erosion evaluation	Shoreline erosion within range of 0.23 to 0.55 acres per year	Not evaluated in 2016, structure not complete	Not evaluated in 2016.

Constraints				
	Monitoring Methodology	Success Criteria	2016 Results	Criteria Met
Avoid Navigation Impacts	Bathymetric Survey	Navigation channel dredging requirements shall not be increased as a result of project construction	Not evaluated in 2016, structure not complete	Not evaluated in 2016, structure not complete
Avoid Littoral Drift Impacts	Aerial Imagery & Bathymetric Survey	No impacts to the littoral drift system inferred from qualitative assessment of down drift shoreline.	Not evaluated in 2016, structure not complete	Not evaluated in 2016, structure not complete
Avoid Shift in Trophic State	Total Phosphorus, Chlorophyll a, and Secchi Disk. Calculate TSI using Chl-a for segments 2-5 in Braddock Bay.	No increasing trends of TP, Chl a, or TSI following construction of barrier beach	Baseline conditions frequently exceed ecosystem target criteria. Success criteria should be based on the occurrence of increasing trends in TP, Chl a, or TSI in years after barrier beach is created.	Not evaluated in 2016, structure not complete
	SAV and Floating Vegetation Survey – Rake and visual Surveys(Bay segments 2-5)	No significant increased in relative abundance of “nutrient enrichment tolerant” species	Not evaluated in 2016, structure not complete 2016 Baseline Nutrient enrichment tolerant species coverage – 35%	Not evaluated in 2016, structure not complete
Other	Barrier Beach Structural Monitoring	-	Not evaluated in 2016, structure not complete	Not evaluated in 2016, structure not complete

FQAI - Floristic Quality Assessment Index

4.0 Monitoring Time Frames and Adaptive Management

Due to the variable nature of the adaptive management monitoring parameters and limitations of funding, not all parameters will be monitored yearly. All adaptive management components will be monitored through 2017. This component along with, navigational impacts, littoral drift, and water quality will be evaluated in 2018.

Table 10. Adaptive Management and Future Monitoring

Objectives				
	Monitoring Methodology	Criteria Met	Adaptive Management	Next Sampling
Wetland Habitat Diversity	Emergent Vegetation	Partial	Continue monitoring with special attention to purple loosestrife and European frogbit. Consider bio control for loosestrife.	2017
	SAV and Floating Vegetation Survey – Rake and sample plots (Bay segments 2-5)	Baseline data collected in 2016	Monitor in 2017.	2017
Habitat Suitability	Fish surveys	Partial species richness increase observed, however, northern pike YOY not observed in channels or potholes.	Continue monitoring.	2017
				2017
	Bird Surveys	Yes	Continue monitoring.	2017
	Amphibian Surveys	Yes	Continue monitoring.	2017
Reduce Erosion	Shoreline erosion evaluation	Baseline data collected in 2016	Monitor in 2017 and 2021	2017 and 2018
Constraints				
Avoid Navigation Impacts	Bathymetric Survey	Not evaluated in 2016.	Monitor in 2017.	2017 and 2018
Avoid Littoral Drift Impacts	Aerial Imagery & Bathymetric Survey	Not evaluated in 2016	Monitor in 2017.	2017 and 2018
Avoid Shift in Trophic State	Total Phosphorus, Chlorophyll a, and Secchi Disk.	Not evaluated in 2016	Success criteria should be based on the occurrence of increasing trends in TP, Chl a, or TSI in years after barrier beach is created.	2017 and 2018
	SAV and Floating Vegetation Survey – Rake and visual Surveys(Bay segments 2-5)	Not evaluated in 2016	None	2017 and 2018
Other	Barrier Beach Structural Monitoring	Not evaluated in 2016	None	2017

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A-1 Braddock Bay Restoration: Adaptive Management Plan

A-2 SUNY Brockport Restoration Monitoring Report - Fall 2016

A-3 Wetland Species List and FQAI Calculations

A-4 Aquatic Habitat Sampling

A-5 September 2016 Aerial Imagery